New records for the Arnhem sheathtail bat *Taphozous kapalgensis* (Chiroptera: Emballonuridae) from voucher specimens and Anabat recordings

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ABSTRACT

Taphozous kapalgensis was previously known from just nine records. In a recent survey we collected three individuals and identified two more from specimens held by the Northern Territory Museum. Two reference calls were also recorded for this species using the Anabat system. A review of fauna survey data containing an archive of 24400 digital Anabat call files recorded at 742 sites across the northern half of the Northern Territory identified 162 files from nine sites that matched the *T. kapalgensis* reference calls. We recommend, based on the information presented here, that *T. kapalgensis* be regarded as Near Threatened.

Key words: *Taphozous kapalgensis*, rare, bats, Anabat, echolocation

INTRODUCTION

Eight species of sheathtail bat (family Emballonuridae) occur in Australia, five of which are of conservation concern or poorly known. Sheathtail bats are difficult to survey. Surveys are usually conducted near or over fresh water bodies because most microbat species will drink or forage for insects that are attracted to water. However, sheathtail bats are generally high flying and some species do not appear to drink from open water bodies (pers. obs.). Survey methods used in the past for sheathtail bat species include searching for roosts, spotlighting and shooting, and less successfully, mist nets and harp traps. In recent years, new information on some species has been obtained using electronic bat detectors. However, identification of rarer species has not been possible because their calls are often unknown. The Arnhem sheathtail bat *Taphozous kapalgensis* was known from just nine records prior to those described here. Four individuals, from which the species was first described, were shot at Kapalga in 1978, in what is now Kakadu National Park; a fifth was collected nearby in 1979 (McKean and Friend 1979); McKean collected another specimen at Kapalga in 1980; that same year an individual was captured and released near Nourlangie camp, Kakadu National Park (D. Matthews pers. comm.); in 1982 a specimen was obtained near Ubirr Rock, Kakadu National Park; and in 1998 an injured *T. kapalgensis* (which subsequently died, NTM U.4852) was collected from the outskirts of Darwin (Figure 1).

Due to this paucity of records and our lack of knowledge of its ecology and distribution, it has been difficult to assess the conservation status and management requirements of this species. *T. kapalgensis* is not listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, was regarded as Data Deficient in the *Action Plan for Australian Bats* (Duncan *et al.* 1999), and is also listed as Data Deficient in the Territory *Parks and Wildlife Conservation Amendment Act 2000*. It is not known whether the paucity of records is a consequence of difficulties in detecting the species using traditional survey techniques, genuine rarity, or a combination of both. It is thought that *T. kapalgensis* generally flies high above the canopy, flying lower when foraging over open areas or unobstructed flyways (Churchill 1998). This type of flight behaviour is not conducive to trapping with mistnets or harp traps but may lend itself to echolocation recording and identification techniques (O'Farrell and Gannon 1999). Here we describe the echolocation call of *T. kapalgensis* that we recorded from free-flying individuals, which were subsequently shot and vouchered for positive identification. Using these calls, we conducted a retrospective analysis on an archive of Anabat call files collected from surveys in the Northern Territory over the last five years.

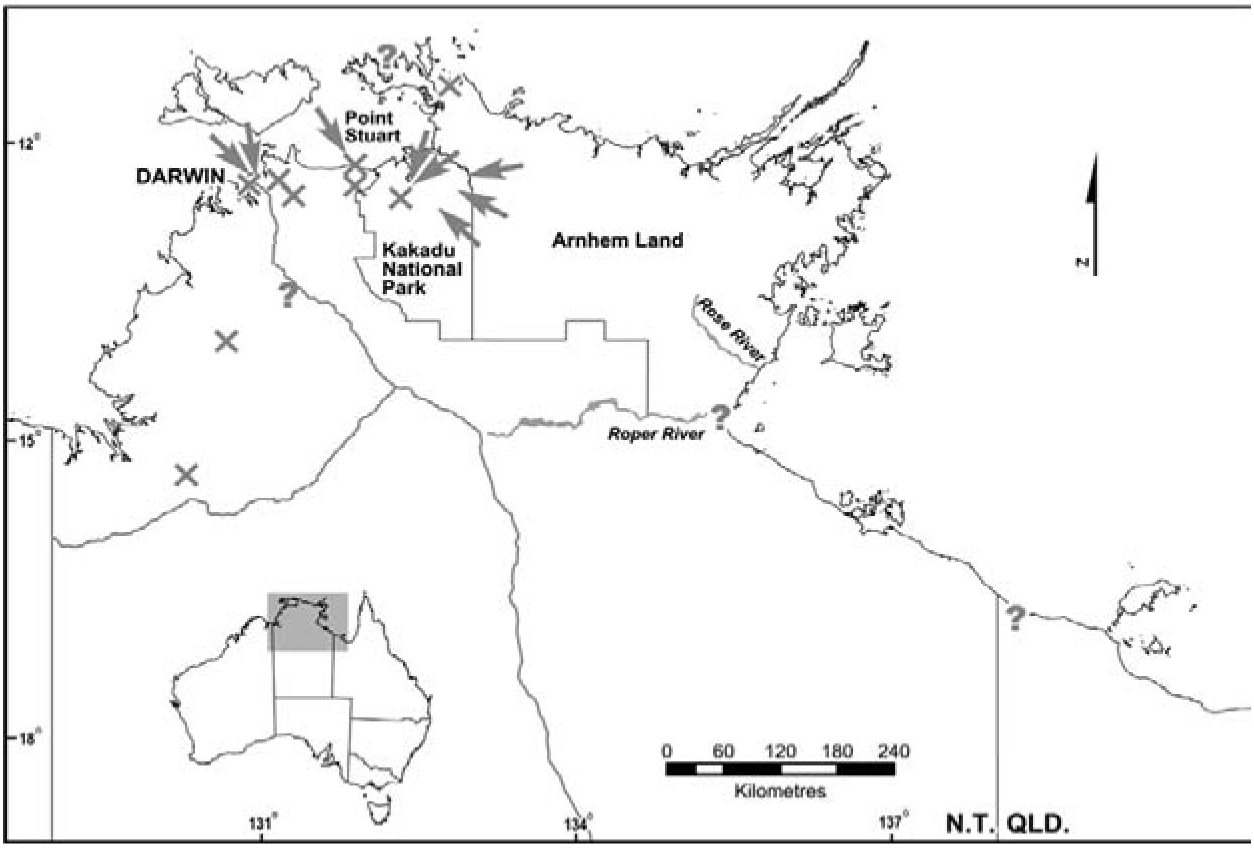


Figure 1. Location *T. kapalgensis* records. Crosses show sites where *T. kapalgensis* was identified from Anabat recordings. Sites at which Anabat call sequences were similar to the reference calls for *T. kapalgensis*, but could not be attributed with certainty to this species, are indicated by "?". Arrows indicate where *T. kapalgensis* has been physically caught or collected.

Collection of *T. Kapalgensis* and recording of reference calls

On the 23 October 2001, a large, free flying microbat was detected and recorded using an Anabat II bat detector (Titley Electronics, Ballina, NSW) and tape recorder (Optimus CTR-115 and Sony UX Chrome cassette-tape). During recording the bat was visually detected using a spotlight and then shot. The specimen was subsequently identified as *T. kapalgensis*. A 20-second call sequence was recorded and transferred to computer using an Anabat 6 ZCAIM and Anabat5 software. The Anabat detector was held in the hand, manually activated on detection of the call and pointed in a direction to obtain the best call reception. The adult male specimen was lodged in the Museum and Art Gallery of the Northern Territory (NTM U.5294, body mass at capture 29.5g). The location was on the Point Stuart Coastal Reserve, 116 Km ENE of Darwin (12°14'47"S, 131°53'02"E). The environment consisted of coastal floodplain adjacent to low woodland of *Pandanus spiralis* with small patches of monsoon forest nearby. The floodplain is subject to inundation during the wet season (November - April). The environment is similar to that described by McKean and Friend (1979) where the type specimen was collected, 63 km SE of our collection site.

Two more specimens were collected in the same manner during a follow-up survey at the same location: an adult female (NTM U.5227, body mass at capture 27.5g) on 3 November 2001; and a sub-adult male (NTM U.5295, body mass at capture 18.5g) prior to dawn on 4 November 2001. We successfully recorded the echolocation call of the first of these bats. A 6-second call sequence was recorded via a hand-held Anabat unit to the analog tape recorder, and a 3.5-second recording of the same call sequence was recorded via a hand-held Anabat unit to a lap-top computer (Toshiba Satellite T1910), running Anabat6 software. All three bats had distinctively coloured orange-brown dorsal fur (as opposed to red-brown fur described by Churchill 1998). However, only the two adult specimens had lateral white stripes of fur on the under-sides of the wings along the sides of the body. The juvenile specimen lacked these distinctive markings.

The collection of *T. georgianus* specimens held by the Northern Territory Museum and Arts Gallery was also checked for specimens of *T. kapalgensis* to investigate the

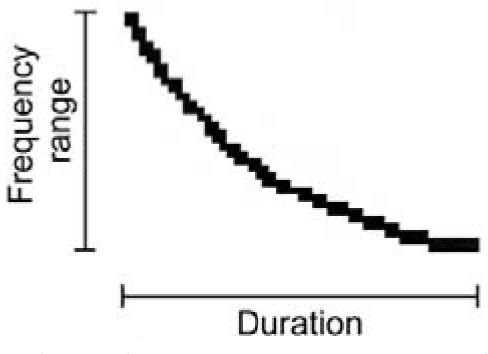


Figure 2. The frequency range and duration of a bat call pulse.

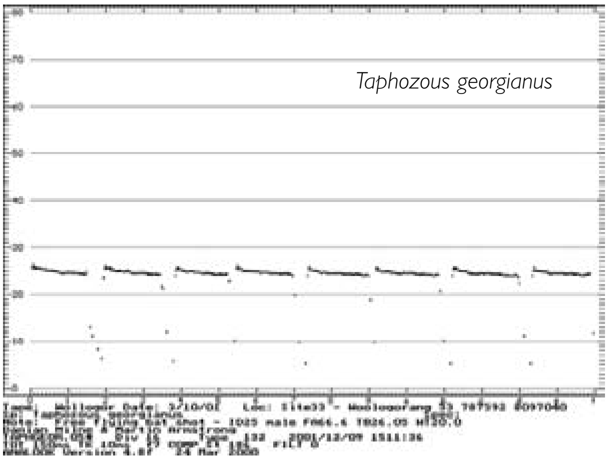
Table 1. Comparison of Anabat call attributes of *T. kapalgensis* with species with overlapping call frequencies. Data were obtained from reference calls collected from the Top End of the Northern Territory except for *M. beccarii* which were recorded in Queensland. Median frequency range and median pulse duration were compared between *T. kapalgensis* and the other four species using the Mann-Whitney U test: NS, not significant; ***P<0.001.

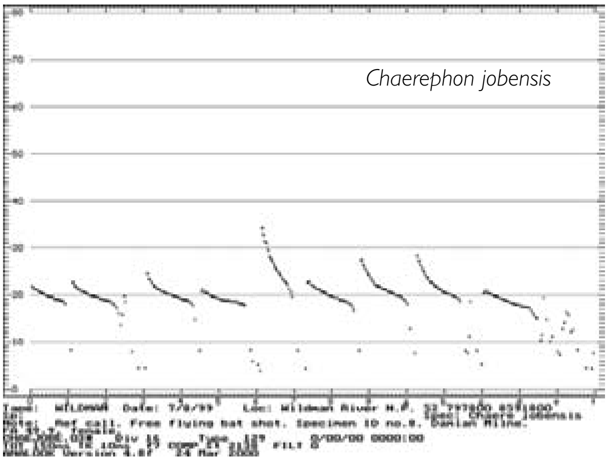
Species	n (pulses)	N (sequences)	Frequency (kHz)					Duration (ms)		
			Min	Max	Median frequency range	95th percentile range	Z	Median	95th percentile range	Z
T. kapalgensis	26	2	22.96	25.48	1.30	0.84-2.04		4.62	3.02-7.02	
T. georgianus	60	6	23.32	25.36	1.40	0.18-2.24	-0.263 NS	11.30	6.93-17.15	-7.316***
C. jobensis	143	6	16.11	24.35	4.65	1.59-14.39	-7.926***	10.15	5.70-16.48	-7.965***
M. beccarii	129	5	21.25	29.09	5.38	2.10-9.58	-7.813***	9.89	5.83-13.13	-7.854***
S. flaviventris	232	18	18.10	24.17	4.65	1.84-7.29	-8.231***	10.36	5.27-20.05	-8.165***

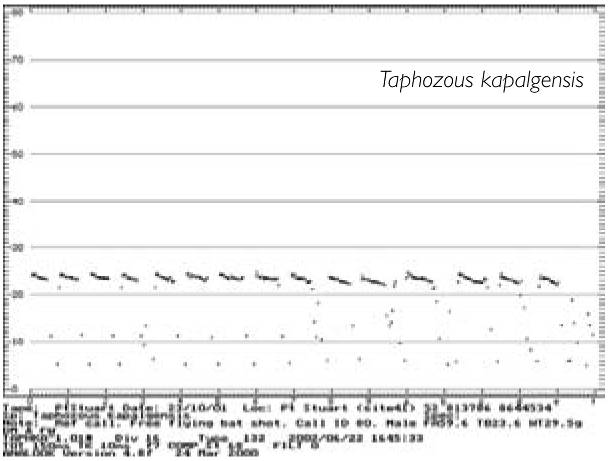
possibility that mis-identifications may have occurred given that the two species are physically similar. Two further individuals were discovered. The first of these specimens, a female (NTM U.4637), was collected in 1997 from the outskirts of Darwin (12°25'39"S, 130°56'03"E). The second specimen was collected in 1982 (NTM U.599) from Magela Creek in Kakadu National Park (precise locality unknown). This was a lactating female with a forearm length of 57.6 mm. Both specimens possessed the orange-brown fur and white fur stripes along the undersides of the wings, however, being soaked in preserving alcohol, their colour appeared much more drab than the *T. kapalgensis* individuals we collected before being preserved, and similar in appearance to many of the *T. georgianus* specimens.

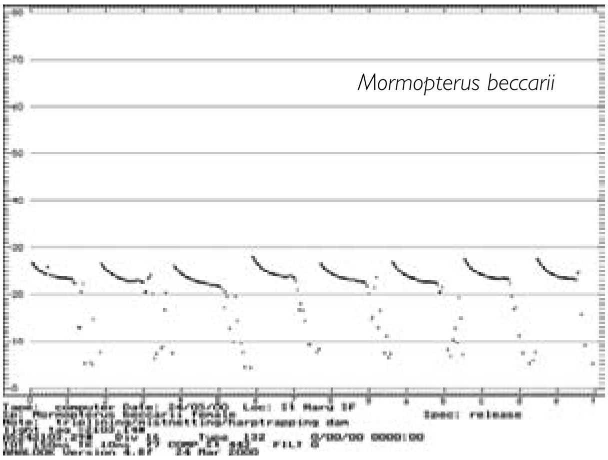
Description of anabat call for *T. kapalgensis*

Echolocation pulses for *T. kapalgensis* derived from an Anabat detector have a frequency band of 22.96 - 25.48 kHz and pulses are relatively short in duration (less than 8 ms). There are four other species in the Top End with call frequencies that are within the band of *T. kapalgensis*: *T. georgianus*, *Chaerephon jobensis, Mormopterus beccarii* and *Saccolaimus flaviventris*. These species can be distinguished from *T. kapalgensis* by the frequency range (i.e. maximum frequency minus minimum frequency) and/or duration of call pulses (Table 1, Figure 2). Both of these features are obvious from a visual comparison of reference calls of all species (Figure 3).









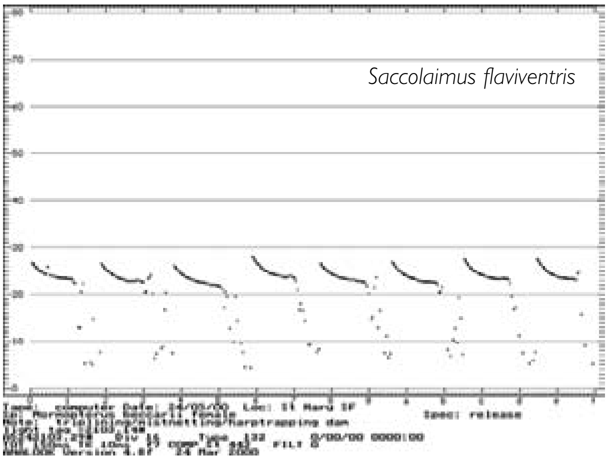


Figure 3. Reference call of *T. kapalgensis* and comparison with typical reference calls of other bat species with overlapping frequencies. Vertical axis represents frequency (kHz), horizontal axis represents time (major tick marks = 10 ms). Views are in the "compressed mode" of Analook to exclude gaps between call pulses.

It is possible that these four species could produce a similar call to *T. kapalgensis* should only part of their call pulses be recorded as a consequence of the bat flying at the limits of the distance at which the Anabat detector can detect their calls. These pulses are unlikely to remain consistent for more than three or four pulses, however, as the distance of the bat from the detector will vary as the bat flies. Therefore, in the review described below, unknown calls collected from Anabat surveys were only attributed to *T. kapalgensis* if at least eight consistent call pulses were observed that matched the *T. kapalgensis* reference calls.

Saccolaimus saccolaimus also overlaps in geographic range with *T. kapalgensis*, however, we have no reference call recordings for this species from the Northern Territory. Therefore, it is possible that calls we attributed to *T. kapalgensis* may have been confused with calls of *S. saccolaimus*. Call recordings of *S. saccolaimus* from Brunei in South-East Asia, have a frequency band of 24.5-26.1 kHz (R. Coles, pers. com.). This is coincident with the frequency band of *T. kapalgensis* (Table 1). However, the call pulse duration of *S. saccolaimus* ranges from 18-25 ms which is much longer than the call duration we measured for *T. kapalgensis* (3-7 ms) and therefore the calls of the two species are unlikely to be confused. One caveat to this statement is that the taxonomic status of Australian and Asian populations of *S. saccolaimus* populations is uncertain (Hall 1995). Calls need to be recorded from Australian populations of *S. saccolaimus* to determine if call characteristics are similar.

Review of anabat archives

DM reviewed an archive of Anabat call files collected since 1997 by the Parks and Wildlife Commission during the course of standard fauna surveys in the northern half of the Northern Territory and north-west Queensland. The archive contained 24400 Anabat call files, which were obtained over approximately 1420 hours of recording from 742 locations north of 22° latitude (Figure 4).

Two sampling methods were used in collecting these calls. At 691 sites, bat calls were recorded for a period of ten minutes during the first 3 hours after dusk within a 50m x 50m quadrat, using a hand-held Anabat II detector as described previously. The second method used static Anabat detectors set on the ground and elevated to an angle of approximately 45°, which recorded calls via either an Anabat II delay switch to an analog tape recorder or via ZCAIM to computer (Toshiba Portégé 3440CT or Toshiba Tecra 700CT) running Anabat5 software. Bats were sampled with this method for a period of either one (10 sites) or two (46 sites) consecutive nights. At sites that were sampled over two nights, bats were also sampled with a hand-held Anabat unit for a period of 3 hours immediately after dusk, concurrently with the static detector.

A total of 162 Anabat files that matched the *T. kapalgensis* reference calls were found from nine sites (Figure 1). A summary of location and environmental features at each site is provided in Table 2. There is a reasonable coverage of survey sites throughout the northern Northern Territory with the exception of eastern Arnhem Land and Tanami Desert. The major landforms and environments, except for arid environments, are also well represented in the sample.

Table 2. Location and environmental description for sites where *T. kapalgensis* was recorded during this study.

Location	Date	Detection method	No. of calls	Environment
15°20'50"S 130°16'35"E	15/3/02	Anabat (10 min.)	1	Extensively cleared area, otherwise open *Eucalyptus* woodland below sandstone escarpment, above major tidal river and floodplain
14°00'40"S 130°39'33"E	22/10/01	Anabat (2 nights)	1	*Eu. tectifica, Corymbia dichromophloia, Erythrophleum chlorostachys* low woodland near head of sandstone escarpment valley
12°26'42"S 130°52'28"E	15/6/00	Anabat (10 min.)	1	Mangroves dominated by *Ceriops* sp. and *Excoecaria ovalis*
12°23'50"S 131°09'14"E	15/12/01	Anabat (2 nights)	2	*Eu. tetrodonta, Eu. miniata* tall coastal woodland
12°33'23"S 131°17'47"E	9/11/01	Anabat (10 min.)	1	*Pandanus spiralis* mixed woodland adjacent to floodplain
12°27'32"S 131°52'55"E	23/10/01	Anabat (2 nights)	4	*Eu. tetrodonta, Eu. miniata* tall woodland adjacent to floodplain
12°14'47"S 131°53'02"E	23/10/01 23/10/01 3/11/01 4/11/01	Anabat (2 nights) individual shot individual shot individual shot	119	Coastal floodplain adjacent to *P. spiralis* woodland with nearby small patches of monsoon forests
12°34'46"S 132°18'59"E	11/10/99	Anabat (10 min.)	1	*Er. chlorostachys, Eu. tetrodonta, Eu. miniata* tall woodland adjacent to floodplain.
11°27'01"S 132°46'59"E	31/10/00	Anabat (2 nights)	32	Grassy coastal dunes with patchy monsoon forest and *Acacia sp.* regrowth

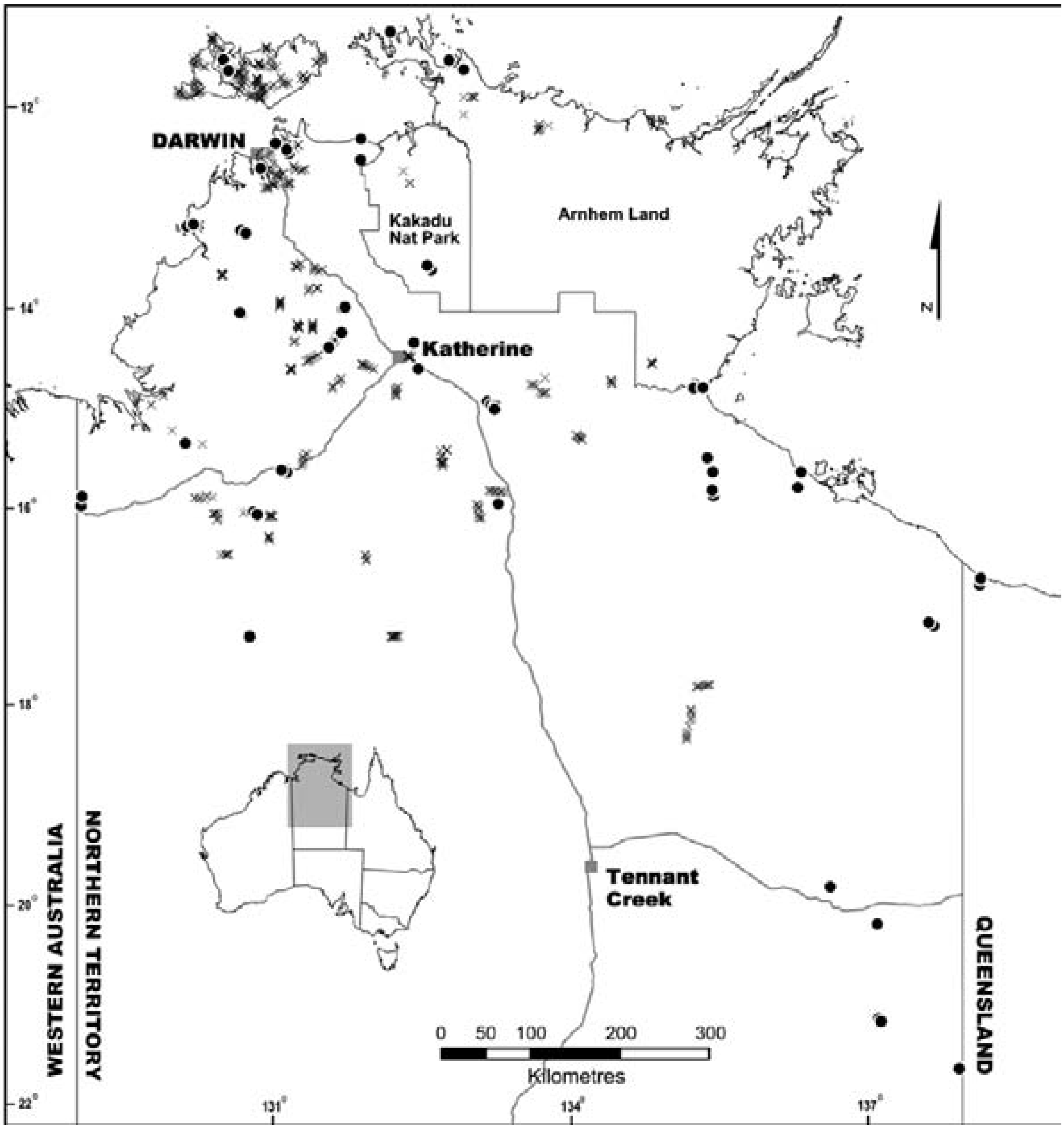


Figure 4. Location of 10 minute (crosses) and 1-2 night (circles) Anabat survey sites conducted since 1997.

Discussion

The collection of two validated reference calls for *T. kapalgensis* allowed us to identify nine new sites where we believe this species occurs based on an archive of Anabat recordings. This is a significant expansion of our knowledge of the distribution of the species. The reliability of these records depends on the accuracy of the reference calls collected and the completeness of reference calls for co-occurring species. A number of considerations which may limit this accuracy should be considered, as detailed below.

Sequences should be indicative of bats in natural flight (Duffy *et al.* 2000). The reference calls collected were almost certainly indicative of bats in natural flight. A long call sequence of 20 seconds was obtained from a free-flying bat before it was collected. The call was unaffected by "post-release stress" (a common problem for reference calls obtained from hand-released bats) and the pulses were consistent throughout the call sequence.

Calls should be recorded from bats flying in the habitats being studied (Barclay 1999). *T. kapalgensis* is generally considered to fly high above the canopy (Churchill 1998). The type of calls produced will be a consequence of the bat flying in unobstructed environments and will generally be unaffected by the habitat over which it is flying. The *T. kapalgensis* individuals that we recorded with the Anabat detector were flying approximately 10-20 m above the ground over a treeless floodplain, therefore we consider that the reference calls we collected fulfil this criterion.

Calls should be obtained from bats within the study area (Barclay 1999). Many of the acoustic surveys included in the review were conducted long distances away from where the reference call was collected. Therefore, there may be intraspecific geographic variation in echolocation calls which has not been accounted for. Nevertheless, calls considered to come from *T. kapalgensis* were a good match to the reference call, and did not match reference calls from any other species known from the study area.

The number of *T. kapalgensis* calls identified in the review of the call archive is likely to have been underestimated for three reasons. First, it is unlikely the entire range of call variation is covered by the two reference calls collected. Other call variants for this species are likely to have been recorded during Anabat surveys but not identified. Second, stringent conditions were placed on the attribution of calls to this species. Normally, the identification of an unknown Anabat recording is based on three or more consistent call pulses (e.g. Duffy *et al.* 2000; Law *et al.* 1998). In this instance, no call sequences were attributed to *T. kapalgensis* unless at least eight consistent call pulses were observed. Nonetheless, comparatively few call sequences matching the *T. kapalgensis* reference call that contained less than eight call pulses were observed. Third, the 10-minute sampling period at most sites is too short a time to gain an adequate representative sample of bats in a given area using echolocation-recording techniques. Law *et al.* (1998) recommend that sampling should take place throughout the night to allow for differences in activity levels during the night.

Nine sites from a total of over 700 had Anabat calls that were attributed to *T. kapalgensis*. Seven sites had recordings of four calls or less for this species, while two sites had more than 30 (Table 2). This observation suggests that the population of *T. kapalgensis* in the Northern Territory is relatively small and is sparsely distributed, but may be locally common. Alternatively, *T. kapalgensis* may be a very high-flying species that is usually out of the detection range of the Anabat detector. This possibility would also reduce the number of sites where *T. kapalgensis* was recorded compared to where it might have actually occurred.

Some caution needs to be exercised when interpreting results where more than one echolocation call sequence was detected at a site. If call sequences were separated by a period of at least 5 seconds, they were regarded as separate calls. Therefore, it is possible an individual bat may have been recorded several times.

Statements by Aborigines that *T. kapalgensis* occurs in the Roper and Rose River regions (McKean and Thomson 1995) were not confirmed by Anabat recordings from one of these areas. A total of 56 hours of recordings at two sites near the mouth of the Roper River did not result in any *T. kapalgensis* calls being observed. However, several of the calls collected (n=34) within the 20 to 30 kHz range could not be confidently attributed to any species (based on Milne 2002), and some of these calls may represent unrecorded variation in the call of *T. kapalgensis*. In particular, two call sequences very closely resembled the reference calls collected for *T. kapalgensis*, but could not be attributed to the species with absolute certainty because the duration of the call pulses was shorter than that measured from the reference calls. This was also the case for four other sites in the Top End of the Northern Territory and Queensland (Figure 1).

The only specific roost site recorded for *T. kapalgensis* is a mine in the Gunlom area of Kakadu National Park (Corbett and Richards 2002) based on Anabat calls recorded at the mine entrance. No *T. kapalgensis* individuals were physically caught and no reference calls for this species were available at the time. Corbett and Richards (2002) attributed Anabat sequences that were a "shallow frequency modulated call of long duration" at 25 kHz to *T. kapalgensis*, claiming that no other species in the Top End could be attributed to this call frequency. However, based on our experience this statement is inaccurate because the Anabat calls of *T. georgianus* are long and almost flat (relative to Anabat reference calls for other bat species) and have a frequency band of 23.3 - 25.4 kHz (Figure 3, Table 1). By contrast, the reference call pulses we collected for *T. kapalgensis* are relatively short. Corbett and Richards did not present Anabat graphs or details of pulse parameters of their *T. kapalgensis* calls and, in our view, the limited Anabat evidence presented by them appears equivocal. In addition, we set a harp trap across the mine adit for one night (leaving a second adit open for bats to freely enter and exit the same mine) eight days after the visit by Corbett and Richards. We failed to trap any *T. kapalgensis*, although three *T. georgianus* were captured. For these reasons, we regard the report of *T. kapalgensis* roosting in this mine with some reservation.

With the exception of four records, the majority of sites at which *T. kapalgensis* has been detected are considerable distances from areas containing rocky habitats that are considered to be potentially suitable for roosting. The distance of three sites from where *T. kapalgensis* specimens have been collected - Darwin, Kapalga and Point Stuart - to the nearest areas of known rocky habitats are 35 km (Daly Range), 60 km (Jabiluka), and 70 km (Mount Bundy), respectively. It is highly unlikely that a cave dependent species would travel so far in order to roost. Jolly (1990) found that the maximum distance that *T. georgianus* flew between roost sites in central Queensland was 12 km, although the author notes the actual foraging distance may have been greater. Furthermore, *Miniopterus schreibersii* has been shown to travel possibly as far as 40 miles (64 km) in one night (Dwyer 1966). There are two other possibilities that may present opportunities for cave roosting bats in these areas. First, there may be sea caves in these areas, which have been shown to support populations of *T. georgianus* on the Wessel Islands off the north-east coast of the Northern Territory (J. Woinarski pers. comm.) and *T. australis* off Queensland's east coast (Richards 1995). Second, road culverts, or disused concrete war bunkers, are also used by cave dwelling bats such as *M. schreibersii* and *T. australis* (Churchill 1998) and therefore may support populations of *T. kapalgensis* if it is a cave roosting species. However, given that the majority of specimens and Anabat recordings that we attributed to this species were from locations considerable distances from areas containing suitable rocky roosting sites, it is more likely that *T. kapalgensis* will roost in trees. This viewpoint is supported by some Aboriginal people who claim the species roosts in the base of pandanus leaves (McKean and Thomson 1995).

T. kapalgensis has been physically captured and ultrasonically detected from most coastal environments (floodplains, mangroves and patchy monsoon forests) and adjacent woodland areas with two notable records occurring in areas adjacent to sandstone escarpments, one of these located a considerable distance from the coast. It is unknown whether these habitats are used for foraging or roosting or whether they simply represent transient habitats for the species. It is possible that *T. kapalgensis* occurs in similar habitats of the Kimberly region in northern Western Australia. However, an extensive survey of bats in mangrove off the Kimberly coastline (McKenzie and Rolfe 1986), which notably included the use of shot-sampling techniques, failed to detect its presence.

Threats to this species will most likely arise from gross habitat modification in the areas where we have shown it to occur. These threats include invasion of large areas of near-coastal floodplain by *Mimosa pigra* (e.g. Braithwaite *et al.* 1989); the replacement of natural floodplain vegetation with introduced pasture species; degradation of habitats by swamp buffalo *Bubalus bubalis*; and saltwater intrusion into coastal plains since the 1940s, possibly also resulting from swamp buffalo activities, and the subsequent death of large stands of *Melaleuca* trees (Mulrennan and Woodroffe 1998). There is currently no evidence that any of these factors pose an immediate threat to the persistence of *T. kapalgensis*, but some concern must arise due to the limited occurrence of the species in a few, possibly isolated populations.

We recommend that systematic Anabat surveys be undertaken in poorly sampled areas of the Top End, particularly the Arnhemland coastal regions, in order to better define the distribution and habitat of *T. kapalgensis*. Further reference calls for the species should be collected from across its suspected range to determine the degree of call variation, in order to increase the effectiveness of surveys using echolocation techniques. Reference calls for *S. saccolaimus* need to be collected from the Northern Territory to determine if its echolocation call can be clearly distinguished from *T. kapalgensis* calls. Clarifying the roosting preferences of the species using radio telemetry should also be a focus of future research.

Based on our study, *T. kapalgensis* is known to occur at no more than ten locations. This fulfils one of two criteria for a species to be regarded as Vulnerable under the IUCN (2001) criteria used to define conservation status. However, there is no evidence to indicate a decline in population size or available habitat, to meet the second criteria. We therefore recommend, based on the information presented here, that *T. kapalgensis* be regarded as Near Threatened (NT). However, this classification should be reviewed once more is known about the species.

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